Energy Flow Within Jets

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July, 2002

MLLA - Theory

H C A L

$$dN/dy = (4/3)[\Gamma(B)/\pi]\int_{-\pi/2}^{\pi/2} d\tau e^{-B\alpha}\{[\cosh\alpha + (1-2p)\sinh\alpha]/[4/3Y(\alpha/sinh\alpha)]\}^{B/2}$$

$$I_B(\sqrt{(16/3)Y\alpha/\sinh\alpha[\cosh\alpha + (1-2p)\sinh\alpha]})$$

$$y = \log(1/x), \quad x = 2k/M$$

$$Y = \log(2M\sin\theta_c/Q)$$

$$p = 1 - y/Y$$

$$\alpha = \alpha_o + i\tau$$

$$\tanh(\alpha_o) = (2p-1)$$

$$B = 101/81$$

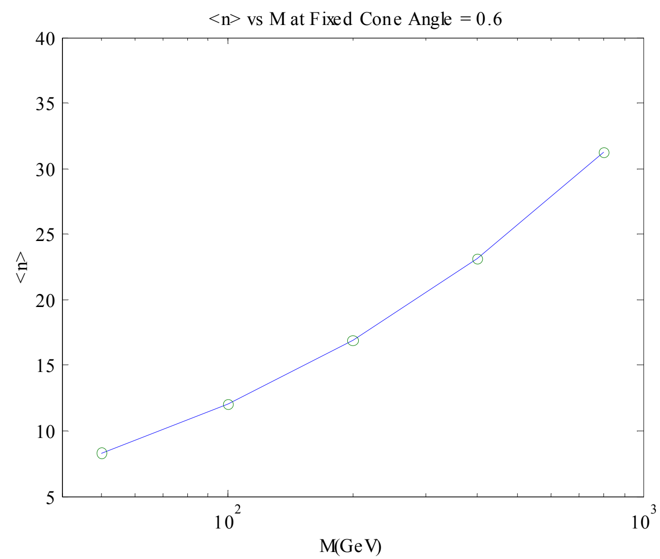
$$Q = 0.23\,GeV$$

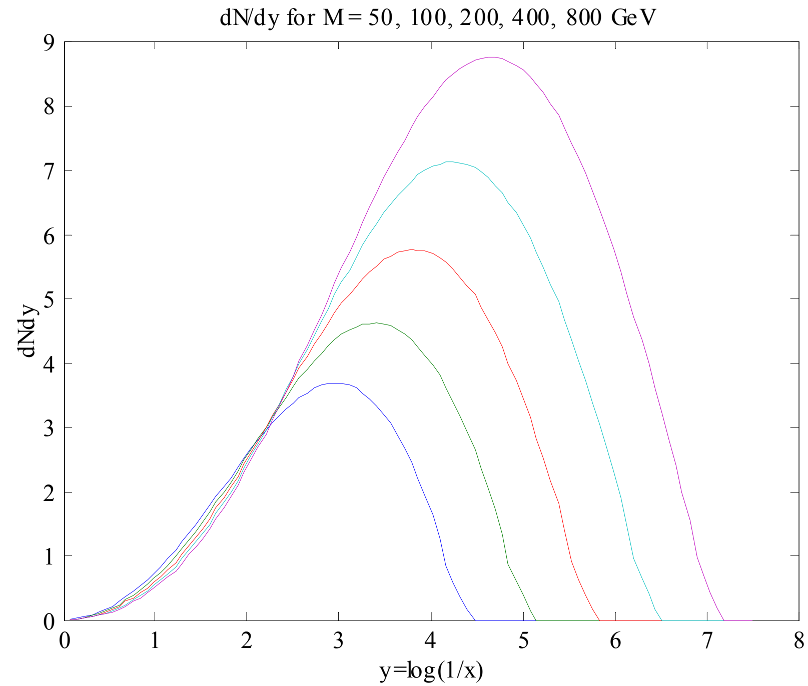
$$N = \Gamma(B)(z/2)^{1-B} I_{B+1}(z)$$

$$z = \sqrt{16/3}(Y)$$

QCD in LLA predicts the x distribution of partons. LPD then gives hadron distribution in x in terms of basically 1 parameter. The value of Q is taken from CDF fits to data. The theory appears in J. Mod Phys. A 1875 (1992) and Z Phys C, 55, 107 (1992). The CDF fits appear in Fermilab – Pub – 02/096-E (June 2002).

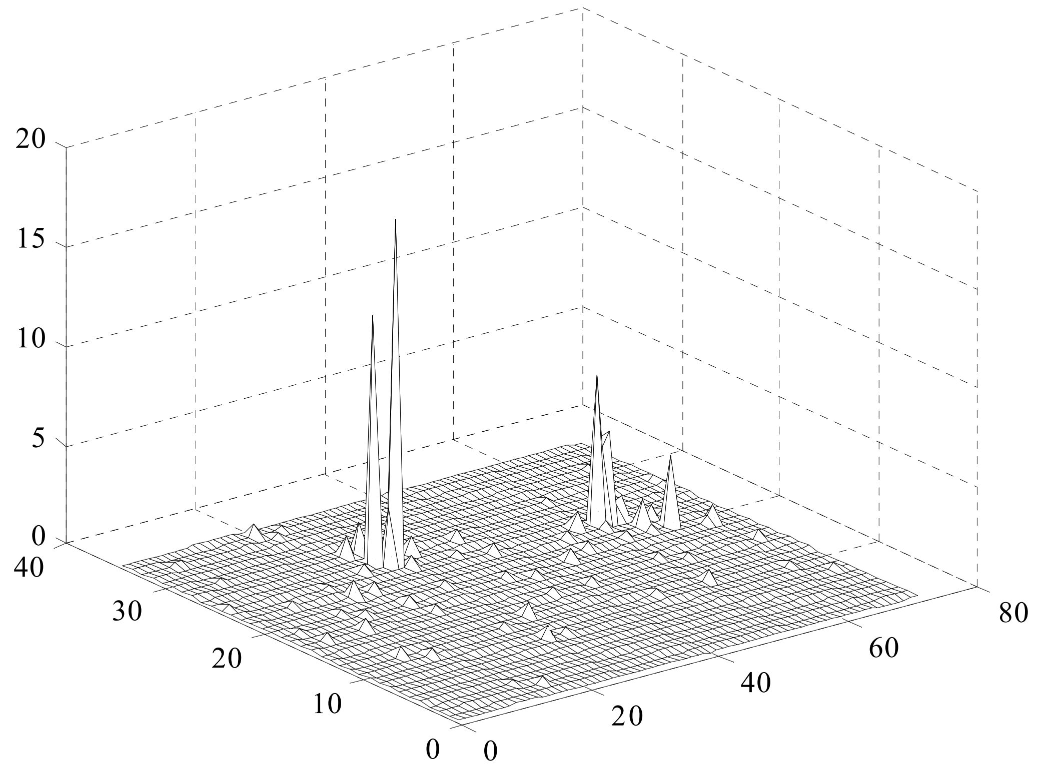
MLLA - Numerical





Numerical results were calculated. <n> increases rapidly with cone angle up to ~ 0.8. We expect ~ 30 hadrons in the jet at M=700 GeV., ~ 12 at M = 120 GeV. We can use D(z,M) as a guide to pileup in extracting jets. Basically angular ordering means that soft jet fragments occur at wide angles w.r.t. the parton axis.

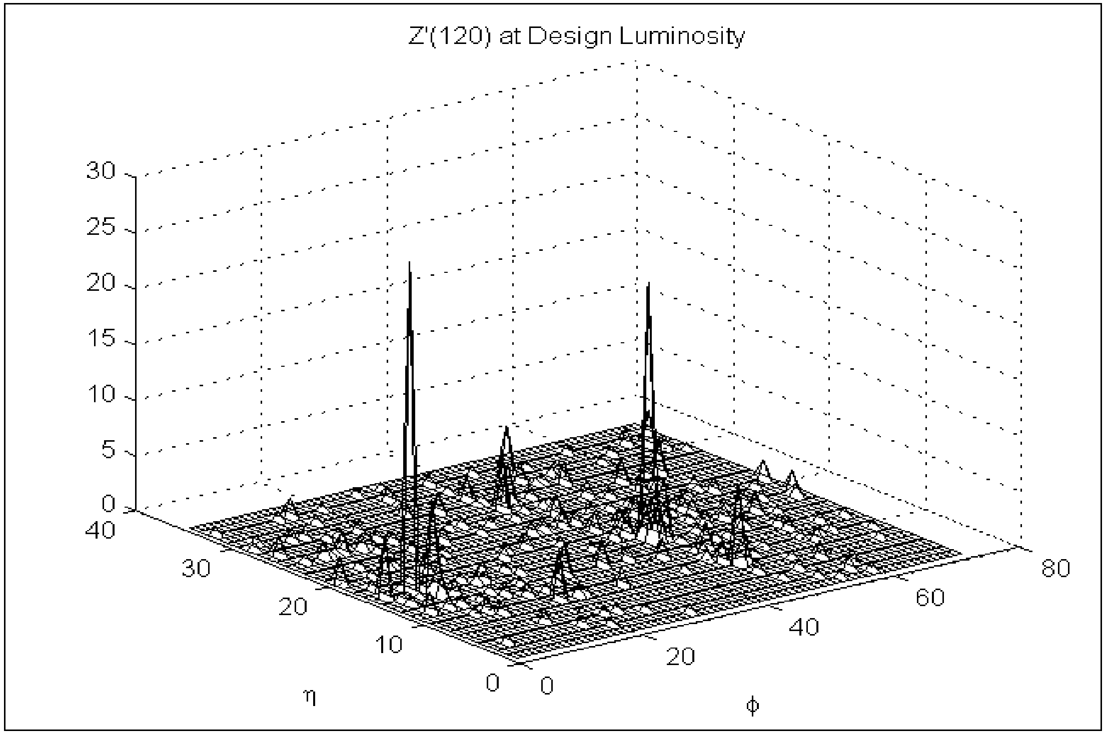
Z'(120) Clustering at Low L



20 seeds > 1 GeV. 8 cones, R = 0.9, 8 jets, Rsep = 0.9. 27, 19 clusters (Et > 0.5 GeV in 2 highest Et jets). Find all seeds, then attach all clusters to cones, Rc, centered on seeds. Finally merge cones within Rsep. Etj1 = 49 GeV, Etj2 = 37.9 GeV, Mjj = 85 GeV

Z'(120) at Design L

H C A L



Clearly, towers are still sparsely populated. Equally clearly, we need to work harder to preserve the dijet mass resolution.

Seeds, Clusters, Cones

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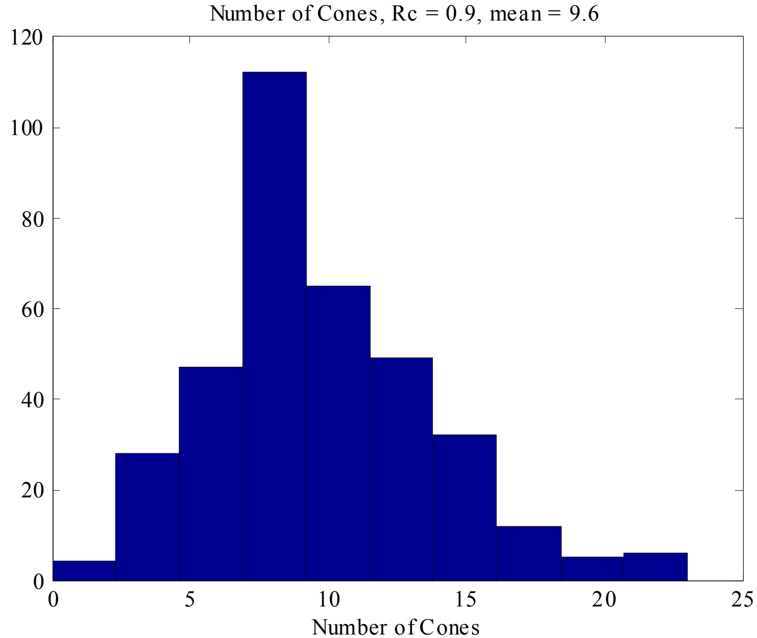
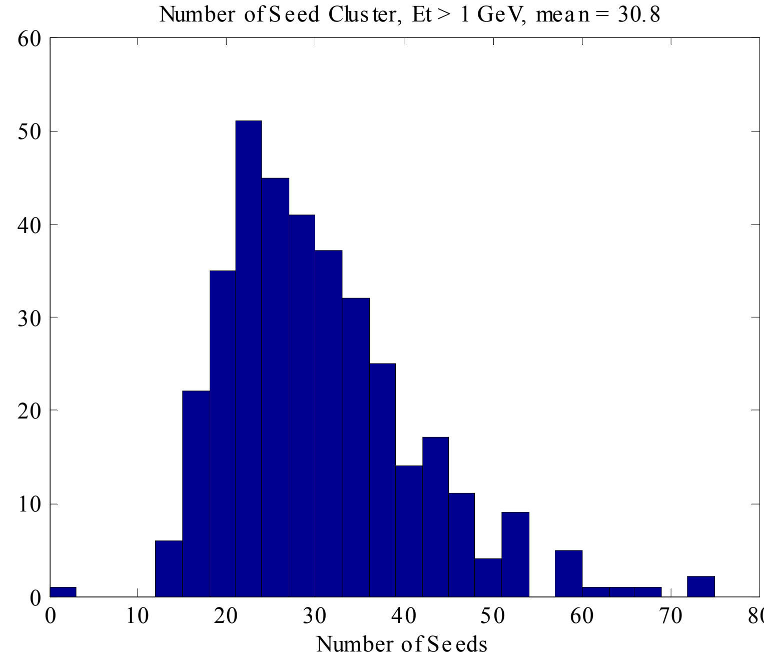




<Ns> = 30.8/event

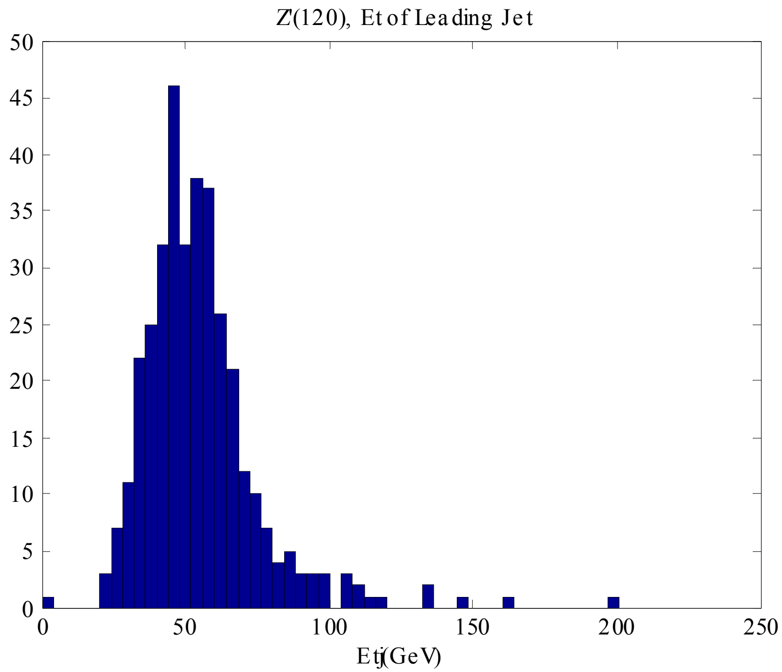
<Nc> = 9.6/event

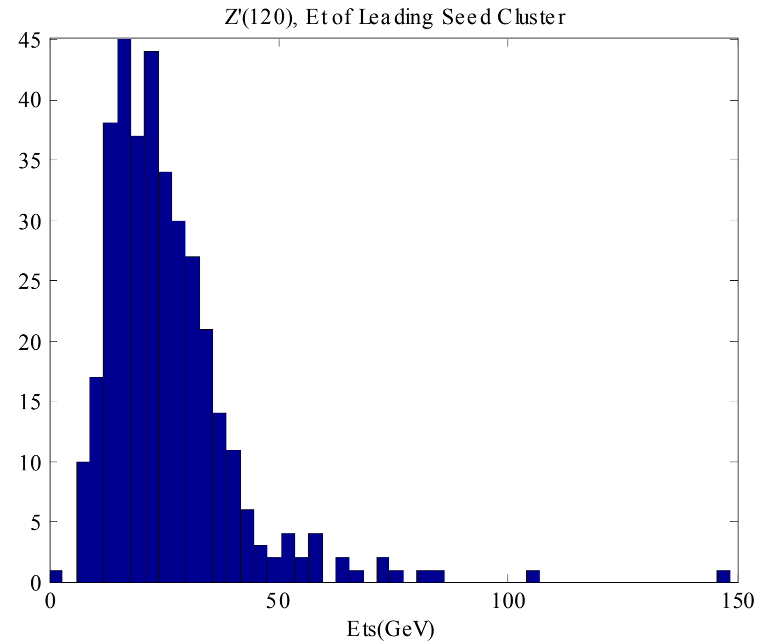
<Nj> = 9.3/event

Ets> 1.0 GeV, Etc > 0.25 GeV, Rc = 0.9, Rsep = 0.9.

There are many jets if seed threshold is made low.

Leading Jet



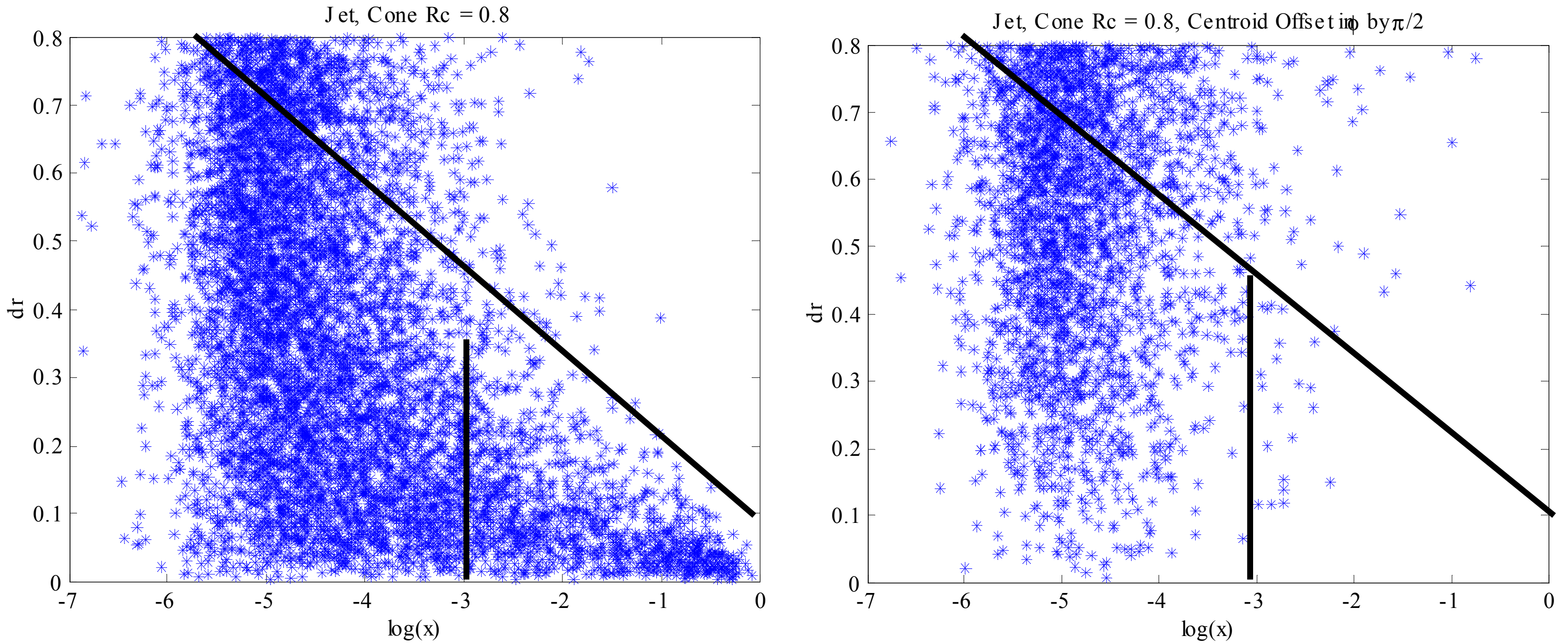


<Ns>j1 = 21 = # clusters in lead jet

<Et>sj1 = 25.0 GeV = Et of seed cluster in lead jet

<Et>j1 = 55 GeV (45.0 GeV for j2)

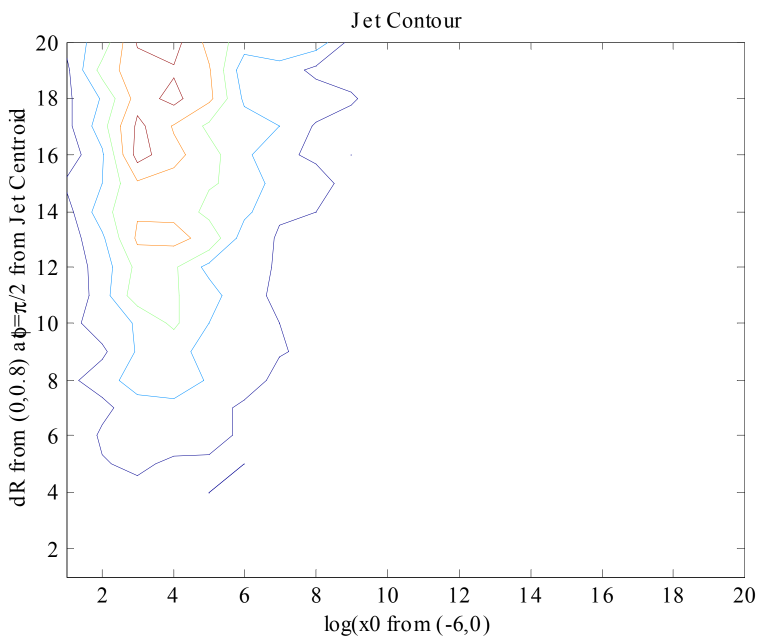
Pileup in Z'(120) at Low L

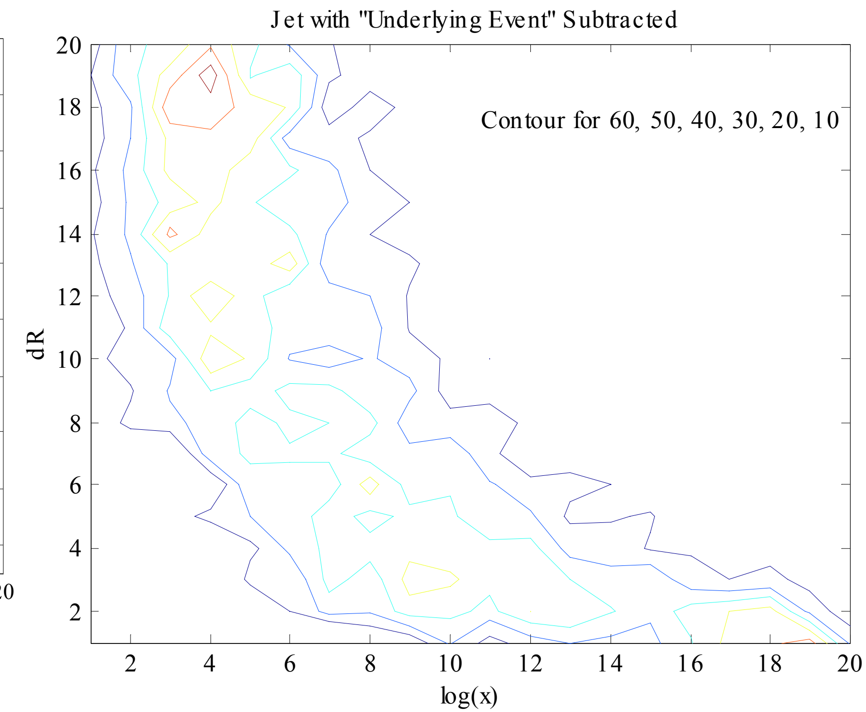


Use log(x) as the appropriate variable (MLLA). The jet shows the small angle, high momentum component. A cone at 90 degrees to the jet shows soft and wide angle underlying event and pileup behavior. Cuts are picked for high L.

The sigma/mean is 17.8% at low L.

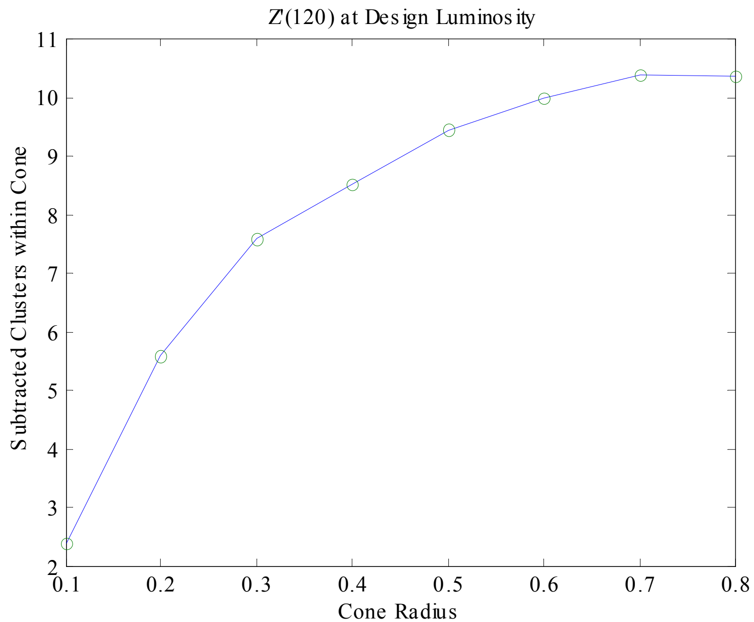
Contours in Z'(120)

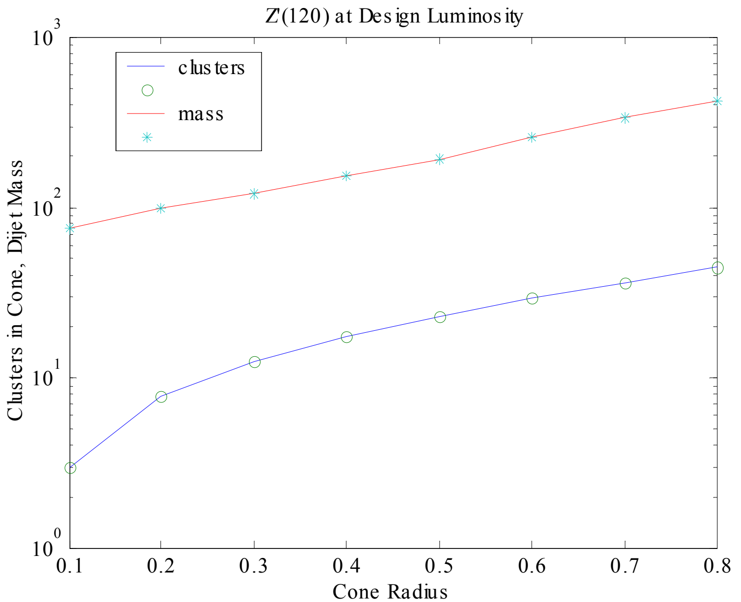




Estimate the true contour in (logx,dR) for a jet by subtracting the cones contour at 90 degrees to the jet for Z'(120) at low L. The pileup and the jet populate different regions of the energy-angle flow phase space.

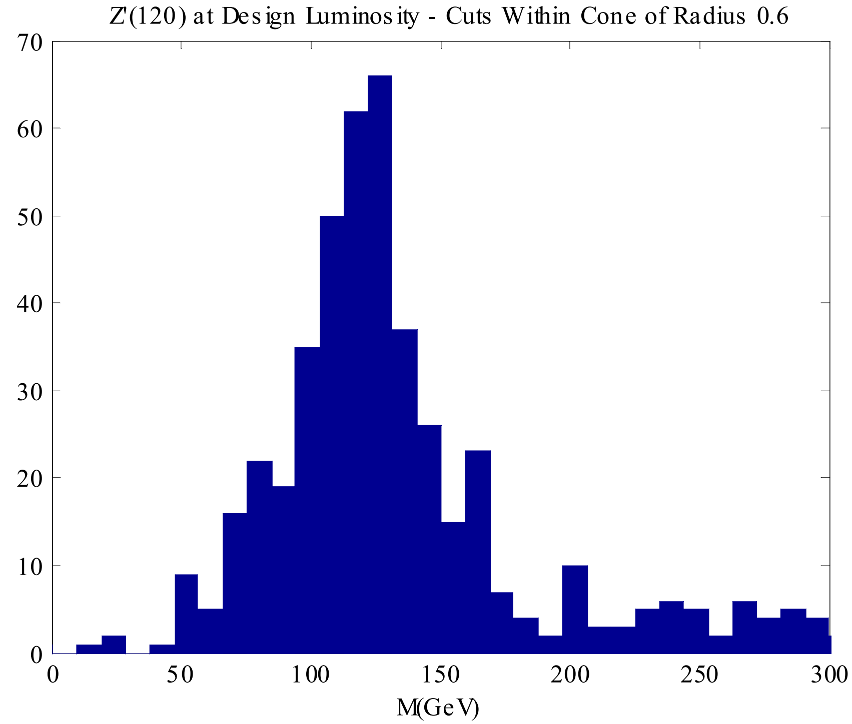
Pileup Subtraction





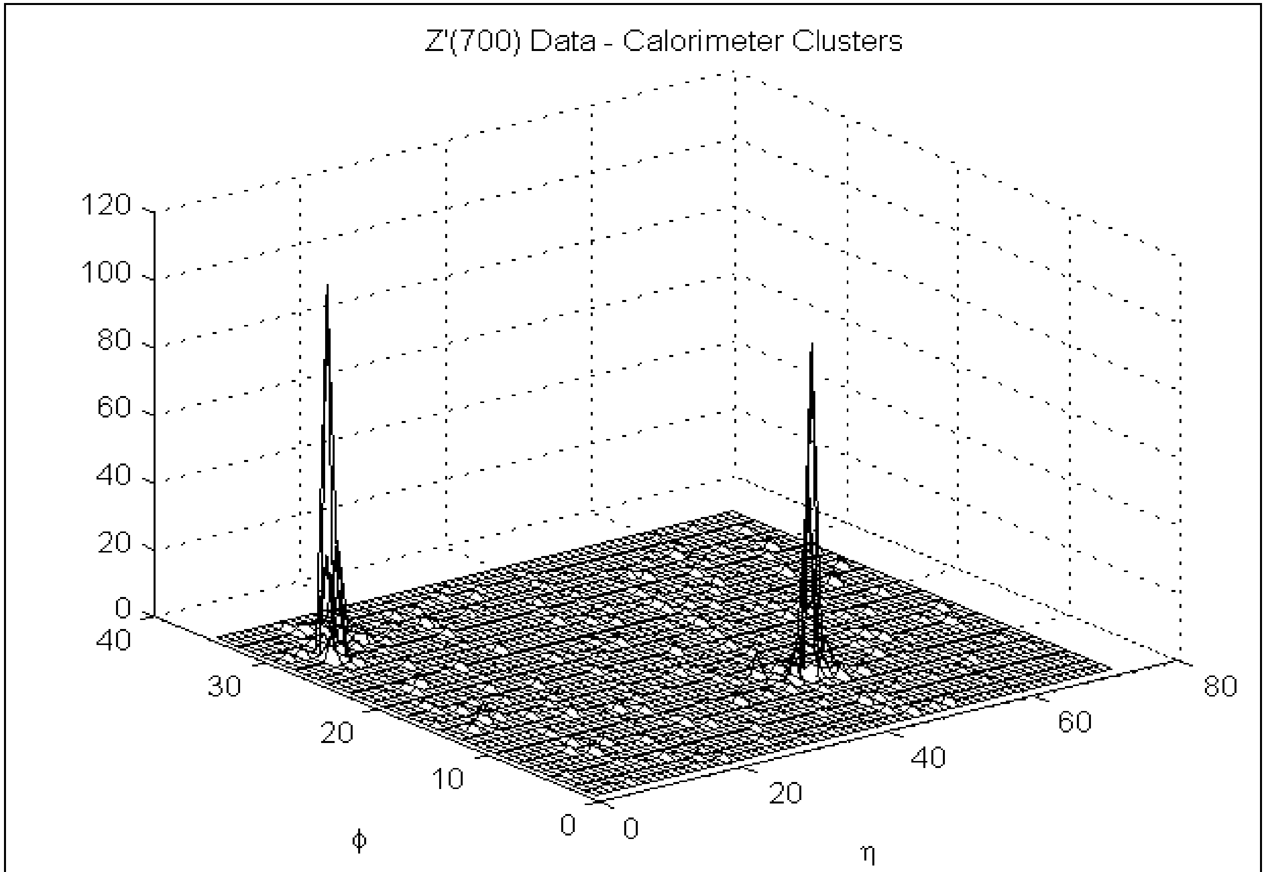
Must go to cone radius ~ 0.6 to capture all the jet fragments on average. However, the number of clusters is ~ 29 then (10.3 real + 18.3 pileup) and the mean dijet mass is 258 GeV

Z'(120) at Design L



After cuts on dR and logx the fitted mean is 119 GeV with a fitted sigma = 20.26 GeV or sigma/mean = 17.0 %. Thus the dijet mass resolution is maintained at design L. There is some residual high mass tail, however.

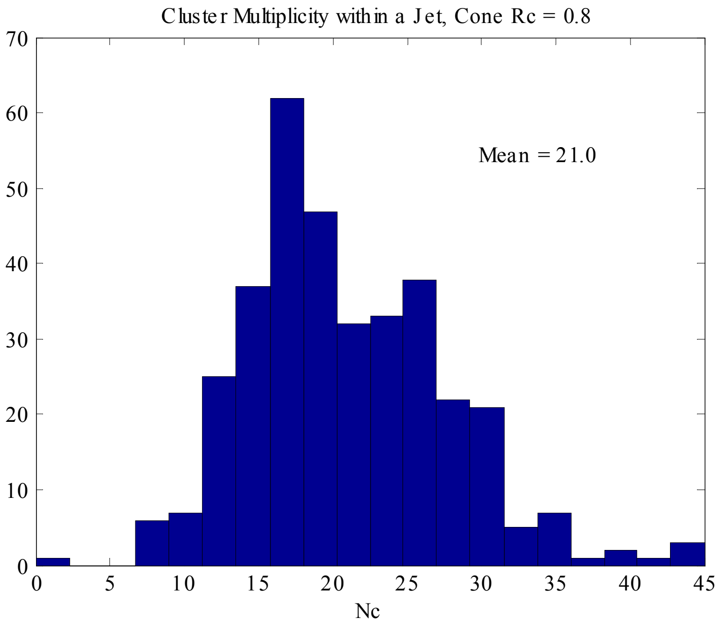
Z’(700) at Design L

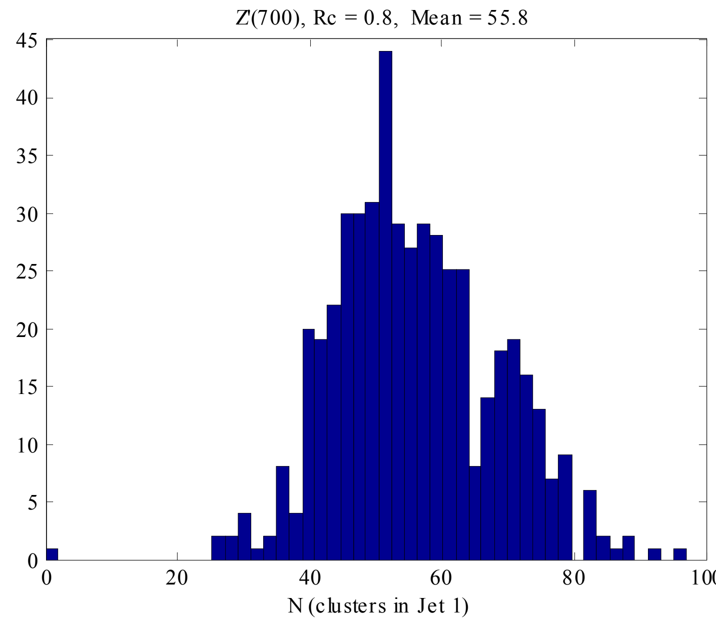


Z’(700) at Design L

- Seed Et > 10 GeV, <Ns> = 10.4 , <ETs1> = 198 GeV (leading seed cluster).
- Cone Rc = 0.8, <Nc> = 3.33
- Jet – Merge Cones, <Nj> = 2.72
- Clusters in Jet - <Ncl> = 55.5
- Clusters at 90 degrees to jet, <Nclo> = 36.4. Difference = 19.1 (expect more in LLA, but there may be cluster merging at high density within the jet).
- <Etj1> = 352.2 GeV

Clustering

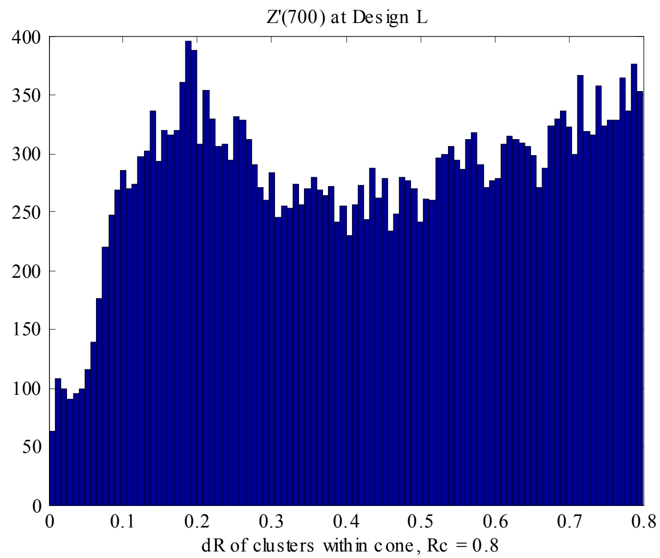


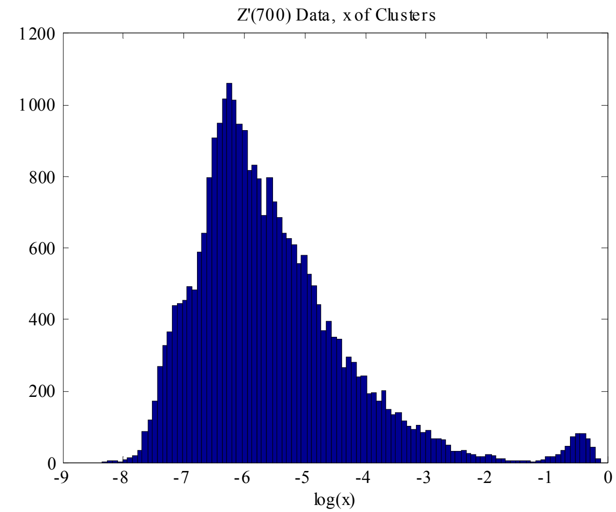


For Z′(120) there are 24 clusters, Rc = 0.9, within the jet and 10 at 90 degrees – leading to 14 after subtraction. This is close to MLLA estimates. For Z′(700) at design L, the number of clusters within a cone is much larger due to pileup, 55.8. For 1/5 luminosity it is 21 clusters. For design luminosity it is ~ 56 – 36 clusters or ~ 19.

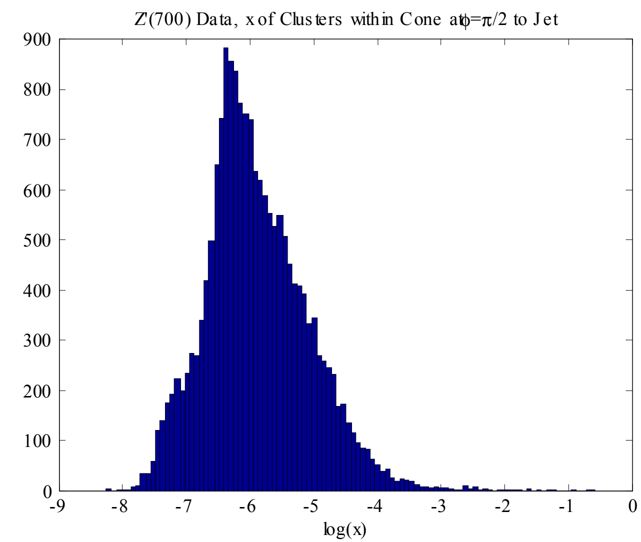
H C A L

dR and log(x) for Z'(700)

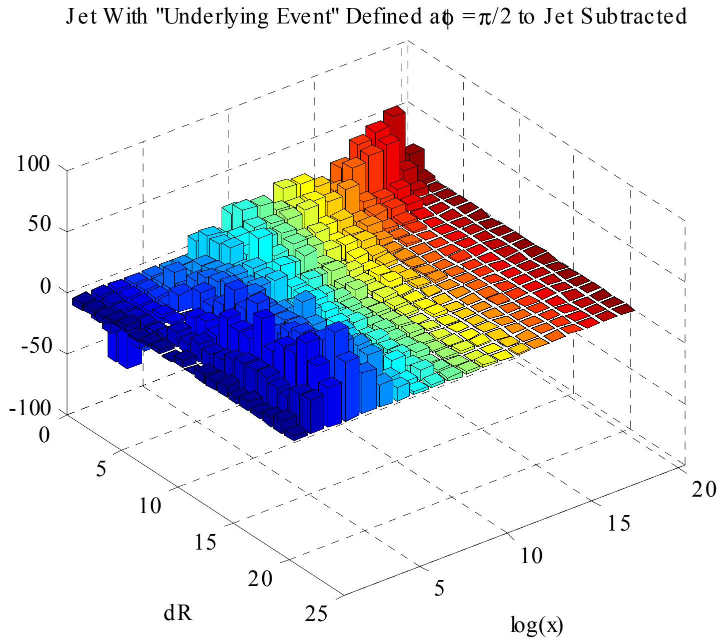


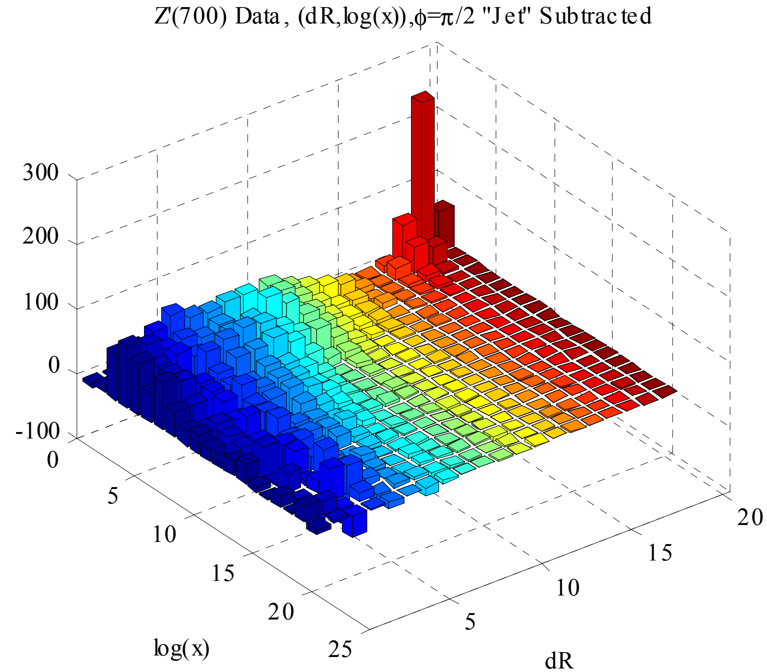


Clearly the pileup has dNdR~R (area), while the jet shows a peak at R ~ 0.2. The pileup is al low x, while there is a peak at high x.



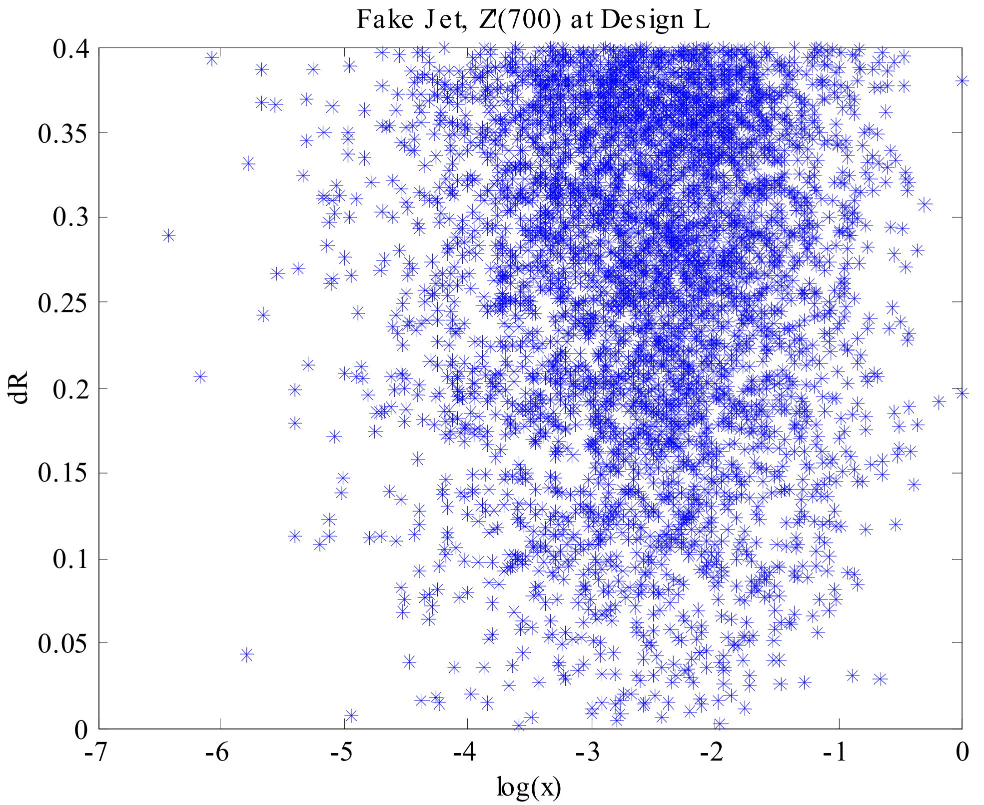
Pileup Subtracted (logx,dR) Jet contours





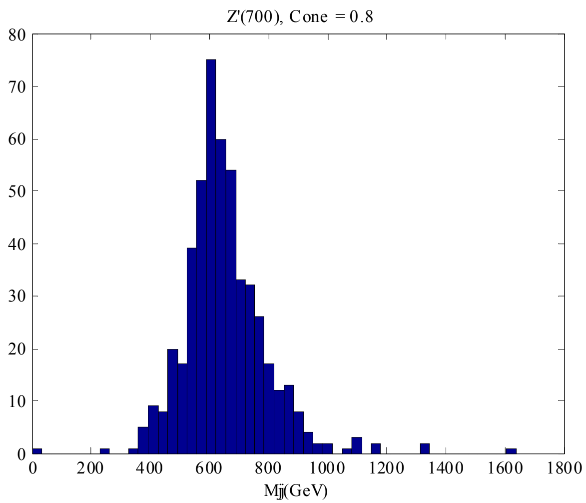
For both Z′(120) at low L and for Z′(700) at design L there is a core of the jet at small dR and large x.

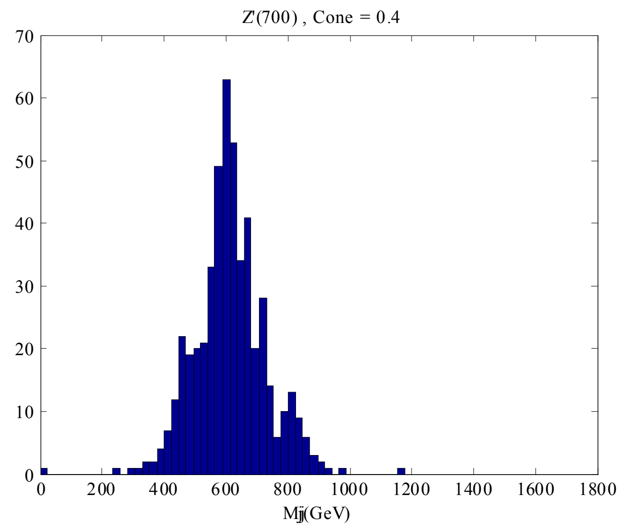
Fake Jets at Design L



Look at fake jets by taking cone at 90 degrees to jet at design L and normalizing x now to total Et within that cone. There is no jet "core" of high momentum at small angles.

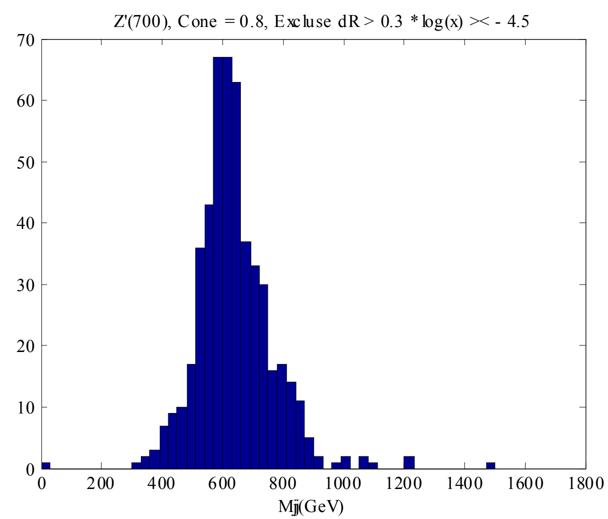
Dijet Mass in Z'(700)





Mean ~ 614 GeV, sigma ~ 74 GeV. No major improvements.

Rc = 0.4 or log(x) > -4 or a combined cut all about the same.



Conclusions

- The pileup at design luminosity is not too severe for Z'(700).
- The appearance of a low Pt inclusive pileup ~ uniform in cone area is confirmed.
- Pileup for Z'(120) is severe but it can be alleviated with well designed cuts on energy – angle flow within the jet.More incisive cuts than just a small cone or a threshold work well.
- Direct subtraction event by event does not work well.